MODELING THE CLASS OF SERVICE CHOICE OF RESIDENTIAL TELEPHONE CUSTOMERS

BY

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There are two major public utility industries in the United States today: telecommunications and electricity production. The pricing schemes of the two have not been very similar. Electric utilities have always charged separate prices for access and usage. That is to say that electric utilities have charged a fee for connection to the system and also a fee based on the consumption of electricity. Most telephone companies have combined local charges for access and usage into a single fee or flat rate. There is currently a strong movement under way in the telephone industry to unbundle access charges and usage charges for local telephone service. Pricing schemes with separate access and usage charges are called measured service options.

The Bell System decision to make local measured service or, LMS, optional presents some special prediction problems

if revenues are to be estimated. Predicting which option a household will choose involves analyzing a selection problem, referred to as the choice of class of service. The percent choosing measured service is known as the "take rate" in the vernacular of the telephone industry. This study will focus on predicting the "take rate."

The choice of class of service is modeled in a logit framework. The nested logit procedure is employed as the estimation method because of its utility maximizing basis, its relative computational simplicity, and its ability to model choice processes in which some decisions are more similar than others, as is presumed to be the case in the Southern Bell experiments. The two measured options may be viewed by customers much less distinctly than the flat rate option versus either measured option.

The three major findings of this study are that the measured options are perceived as being very similar, many personal calls may originate from businesses if the pricing structure is changed, and that the flat rate price will have to be nearly doubled before the "take rate" for flat rate pricing is significantly diminished.

CHAPTER I

INTRODUCTION

There are two major public utility industries in the United States today: telecommunications and electricity production. The pricing schemes of the two have not been very similar. Electric utilities have always charged separate prices for access and usage. That is to say that electric utilities have charged a fee for connection to the system and also a fee based on the consumption of electricity. Most telephone companies have combined local charges for access and usage into a single fee or flat rate. There is currently a strong movement under way in the telephone industry to unbundle access charges and usage charges for local telephone service. Pricing schemes with separate access and usage charges are called measured service options. This chapter presents several reasons for the attractiveness of local measured service, along with the special problems it creates.

Before discussing the advantages of local measured service (or LMS) it is necessary to understand an important objective which constrains the decisions of the telephone industry, namely the universal service goal. One of the objectives of the telephone industry has been to provide

local service in such a way as to make the service affordable to as many people as possible. More than simply industry propaganda, the universal service goal is implied in the Communications Act of 1934 which states that its purpose was to

> . . . make available, so far as possible, to all people of the United States a rapid, efficient, nationwide, and worldwide wire and radio communication service with adequate facilities at reasonable charges . . .

The universal service goal has been implied more recently in the Van Deerlin committe bill, HR 3333, the Hollings committee bill, S. 611, the Communications Act of 1979, and the Communications Act Amendments of 1979.[1] Although the Communications Act of 1979 and its Amendments did not become law, they stated, along with the committee bills, the current legal endorsement of universal service. Any changes in pricing policies by the telephone industry must be made in the context of the universal service goal. With this understanding one may proceed to examine the circumstances which make LMS desirable.

LMS has recently become an attractive alternative to flat rate service due to changes occurring in the regulation of the telecommunications industry. As Garfinkel and Linhart (1979) point out, the FCC has recently encouraged competition in the intercity and terminal equipment markets. Execunet and Graphnet now provide long distance services outside the Bell System's Long Lines division. Additionally, in April of 1980 the FCC handed down the Computer II ruling

which forced the unbundling and detariffing of customer provided equipment by March, 1982.[2] Revenues from the intercity and terminal equipment markets have been traditionally been used to subsidize local telephone service. Without this subsidy, local service will require other sources of revenue. The simple solution to this problem under a flat rate pricing scheme would be an increase in the flat rate. This solution could, however, price some customers out of local service which would be a step away from the goal of universal service.

LMS provides an alternative solution to the problem of increased local revenue requirements. By charging separate access and usage charges, the telephone industry can offer pricing schemes with lower access charges to promote universal service. With a usage charge, increased calls result in increased revenues making subsidies unnecessary.

Current economic conditions have led to increased local calling for two reasons. Recent increases in energy prices have increased the price of local travel relative to local calling. This has resulted in increased local calling since some of the search activities previously handled by travel are now being done by telephone.[3] A similar problem has arisen in the cities. As urban areas have become larger, customers in those areas have insisted upon larger local service areas. This increase in local service in cities like Houston, Minneapolis, and Denver has been achieved by increasing the flat rate prices. Increasing flat rates for

either reason could make local service too expensive for some. Once again LMS provides a possible solution.

LMS is desirable because as Garfinkel and Linhart (1979) indicate it will promote a more efficient allocation of resources for both telephone companies and telephone customers. By bringing prices more in line with marginal costs, telephone companies' investment decisions and telephone customers' usage decisions will be improved. The current flat rate pricing scheme takes no account of peaks and valleys in local calling patterns. From the standpoint of economic efficiency, those customers impinging on capacity should be given some pricing signals related to the costs in order to allow them to cast their dollar votes in an intelligent manner. Those customers desiring greater capacity will pay for that capacity.

Garfinkel and Linhart (1979) also cite inflation as another reason for examining LMS. Flat rate prices have risen recently, which may price some individuals out of telephone service. Those customers on fixed incomes have been especially affected. LMS once again can alleviate the problem.

Finally, LMS has recently become practical because technology now permits local usage to be monitored for $5 per year per line, down from $60-$75 per line in 1970.[4]

It seems that many convincing arguments can be made for LMS so it is not suprising that telephone companies have responded favorably to such structures. According to

Schmidt (1979), G.T.E. plans to switch to mandatory LMS, while the Bell System intends to offer LMS options to its residential customers. The Bell System plans to offer two measured options: a standard measured service option, and a low-use measured service option in addition to the current flat rate option. Residential customers in some areas may also choose a combined flat/measured option with an expanded local calling area. The decision by the Bell System to implement measured service as an option appears to be motivated by marketing considerations. The introduction of measured options may be acceptable to the public without much controversy.

The Bell System decision to make LMS optional presents some special prediction problems if revenues are to be estimated. Predicting which option a household will select involves analyzing a selection problem, referred to as the choice of class of service. The percent choosing measured service is known as the "take rate" in the vernacular of the telephone industry. This study will focus on predicting the "take rate."

It is important to be able to predict the percentages of customers selecting each rate option because this information is essential for predicting changes in costs and revenues resulting from the implementation of optional LMS. According to Cosgrove and Linhart (1979), the Bell System ultimately intends to increase the flat rate price by enough to cover the costs of offering the measured options. This

will certainly effect the number of people subscribing to each option. A model flexible enough to make predictions on an individual basis in light of these kinds of changes would certainly be useful.

Examined in this dissertation are the factors influencing the decision to choose a pricing option. The data result from several LMS experiments conducted by Southern Bell in Florida. The areas participating in experiments include Jupiter, Delray Beach-Main, Delray Beach-Kings Point, Miami Metro-CGO, Miami Metro-CG1, Orange Park, and Pembroke Pines. The method will be developed and tested on the data from the Jupiter experiment.

The choice of class of service will be modeled in a logit framework. The nested logit procedure will be employed as the estimation method because of its utility maximizing basis, its relative computational simplicity, and its ability to model choice processes in which some decisions are more similar than others (as is presumed to be the case in the Southern Bell experiments). The two measured options may be viewed by customers much less distinctly than the flat rate option versus either measured option. The following chapter presents a review and critique of other approaches to modeling telephone decisions.

Notes

[1]For a more thorough discussion of this legislation see, "The Transition to Local Measured Telephone Service," by Lawrence Garfinkel and Peter B. Linhart, 104 Public Utilities Fortnightly 17, August 16, 1979.

[2]In the matter of Amendment of Section 64-702 of the Commissions Rule and Regulations (Second Computer Inquiry) FCC Docket No. 20828 at 163.

[3]Garfinkel and Linhart, op. cit.

[4]Ibid.

CHAPTER II

REVIEW OF METHODOLOGIES

Very little research has been done on the selection of telephone service; furthermore, the existing studies model the choice process quite differently. The purpose of this chapter is to present a critique of the methodologies used in these studies. To facilitate the review, it is convenient to consider the selection of telephone service as emerging from two sequential decisions. First the customer decides whether or not to purchase telephone service, and then those electing telephone service must choose either flat rate local service or measured local service. Perl (1975, 1978) and Mahan (1979) have analyzed the first decision, while Infosino (1977, 1979)[1] has analyzed the second decision. The methods used to model these two decisions have been very different.

Perl (1975, 1978) worked on the phone/no phone decision, estimating linear probability models, logit models, and probit models.[2] Perl's results indicate that the probability of a household having a telephone increases with the income, age, and education of the head of the household. Perl found that urban households were more likely to have telephones than rural households, and that white households

were more likely to have telephones than black households. Welfare families were found to be less likely to have telephones than non-welfare families. Perl's results also indicated that single males and male heads of households were less likely to have telephones than their counterparts of the opposite sex. Many of these relations were found to be non-linear.

The study done by Mahan (1979) is the only analysis of the grade of service decision within a statistical choice framework. In the analysis, choice of grade of service implies the selection of either a one-party, a two-party, or a four-party line. The customers also chose whether or not to purchase telephone service. No measured service options were available to the customers, so the class of service decision is not addressed by Mahan. The data analyzed were obtained from individual households in North Carolina.

Mahan modeled the household decision about grade of service in a sequential, decision tree framework. This decision process is illustrated in Figure 1. At the first stage, the household must decide whether or not to purchase telephone service. Next, those households purchasing telephone service must decide between purchasing a one-party line or a multi-party line. Finally, those households purchasing multi-party lines must choose whether to purchase a two-party line or a four-party line.

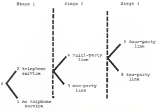

Figure 1. Tree Diagram for the Grade of Service Decision Modeled by Mahan.

Individual household data were used to estimate the probabilities of choosing each alternative at each stage. Linear probability models were estimated for each decision, but were rejected because some of their predicted probabilities fell outside the unit interval. Binary logit analysis was used as the primary estimation method. Although Mahan suggests that polychotomous logit analysis is the proper way to estimate the model, he rejected it because of its expense. Thus, instead of estimating the selection probabilties of all choices simultaneously, Mahan estimates each stage of the decision process individually. At the first stage, all of the data were used to estimate the phone/no phone decision. At the next stage the data on those households purchasing telephone service were divided into single-party and multi-party groups, and the single/multi decision was modeled. The data on those households without phones were not used to estimate stage two. In stage three only data on those households choosing multi-party were used. These data were divided into a "two-party" group and also a "four-party" group and then binary logit model was estimated.

There is a problem with estimating sequential decision models on a decision-by-decision basis. There are only four choices a household can make, and some of these choices are more closely related than others. This being the case, the estimation method employed should account for the similarities of the choices.[3] Sequential logit estimators do

not take account of these similarities. Logit estimation does not permit differential substitution among the choices. This is a consequence of logit estimation which is known as the independence of irrelevant alternatives assumption. This consequence will be discussed at length in Chapter III.

The examination of Mahan's results will be confined to the phone/no phone decision since this choice has the most bearing on the present study. In the phone/no phone equation, the coefficients of many variables were significant and had the expected sign. Income, the number of people in the household sixty or over, the head of the household completing college, and the head of the household completing high school all had the anticipated positive sign and were significant. Dummy variables for the number of people in the household eighteen or over, and a dummy for race defined to be one for black families, zero otherwise, were significant and had a negative sign. The likelihood ratio index,[4] a measure of goodness of fit, for the binary logit models is near .2, and 80% of the households' decisions to purchase telephone service were correctly predicted. Although Mahan covered many topics in telephone demand in his dissertation, his estimation methods are suspect.

Infosino (1977, 1979) has developed a model which predicts the percentage of customers choosing each class of

telephone service. This model bases its predictions on the fraction of customers choosing measured service at each of several calling rates. The following is an outline of what Infosino refers to as the "basic" model.

Initially it is assumed that when a consumer is faced with a class of service choice, the consumer estimates his usage level, and then chooses the class which is cheapest at that usage level. The estimated usage level is referred to as the adjusted usage estimate. It is further assumed that for customers with the same actual usage, the distribution of adjusted usage is lognormal.[5] The next task is to estimate the parameters, α and β, of the lognormal distribution for each calling rate. This estimation is achieved by analyzing the breakpoints at each calling rate. The breakpoint is the number of calls which yield equal bills under two classes of service. Fewer calls lead to lower bills under one option while more calls lead to lower bills under another option. The breakpoint may thus be thought of as the dividing line between choices, if a consumer behaves in a bill-minimizing fashion. There may be several breakpoints depending on the number of options available.

To illustrate the framework, consider the breakpoint corresponding to the lowest number of calls, and call it B_1. This means that from 0 calls to B_1 calls, the selection of some option A resulted in the lowest bill. Suppose that for some calling rate 20% of the customers choose option A. The model suggests that 20% of the adjusted usage estimates for

that calling rate fall between 0 and B_1 calls. Continue until the next breakpoint B_2. Suppose that between B_1 and B_2 calls, the selection of some option B results in the lowest bill. Now, for the given calling rate suppose 50% of the customers choose option A or option B. The model suggests that 50% of the adjusted usage estimates must fall between 0 and B_2 calls. This process has determined, for a given calling rate, two points on the cumulative distribution function of the lognormally distributed adjusted usage rate estimates. These two points are sufficient to determine α and β, the parameters of the lognormal distribution. This process of identifying α and β is then extended to each average calling rate, ultimately yielding several α and β pairs. The β values are then plotted as a function of the calling rate. The line[6] of best fit is then determined, and then the values are redetermined using the fitted β values at each calling rate. The new α values are plotted as a function of the calling rate, and then they too are approximated by a line. With equations for α and β, the model may be used to predict the fraction of customers choosing each class at a given calling rate.

There are several problems with the procedure outlined above. Some of the problems are not too significant, and will not be discussed here. Others are large and render the model inappropriate for investigating the effects of an increased flat rate on the class of service choice.

First the model is not grounded in economic theory. Infosino suggests that customers choose the class of service which minimizes their expected bills. Essentially the idea behind the model is that customers choose the quantity of telephone calls, and then they select the price. There is no mechanism whereby the price can affect the quantity. Utility functions and prices are not mentioned by Infosino.

The model is not useful for identifying individual characteristics which influence the choice. No indication is given as to how economic and demographic variables relate to the choice. The model is unable to suggest how various groups of consumers will be affected by having various class of service options available. This is a matter of great concern to regulators. Thus, the model cannot be generalized to other geographic areas or areas with different socio-economic characteristics.

The model seems to be little more than a descriptive device. The basic model outlined above is applied to data from several different experiments. When the model does not work well it is adjusted. These modifications eventually enable the model to predict well for all of the experiments. The problem is that all of these checks are really only model validation; all checking is after the fact. One does not know initially which model to use if the customers have not yet chosen, and there are no results indicating how to adjust the model. The "basic" model may be used to reproduce existing results, but problems arise when the

model is extended to other data sets. One does not know which version of the model will be the proper one to use.

As has been discussed previously, Southern Bell intends to increase the flat rate charge after implementing the measured options. The model developed by Infosino will be of little use for predicting the effects of changes in the flat rate because the data analyzed by Infosino included calling rate data after customers had switched to measured options. The calling rates were then assumed to be unaffected by the choice of class of service. Since measured options employ, after a usage allowance, a marginal price for calling, this assumption contradicts economic theory. However, the problem may not be too serious for the data analyzed by Infosino because, as he suggests, the flat rate charges in each of the experiments were not too high, so that most customers switching to measured were low-use customers.

Infosino suggests that if the flat rate were increased substantially, customers switching to measured options would decrease or repress their usage. This usage repression contradicts Infosino's model of the customer's class of service choice. In his model, the customer estimates his "usage" and then chooses the option yielding the lowest bill for the "usage." The problem is simply that "usage" is endogenous, since selection of an option with a very high marginal calling price will cause usage to be less. Usage depends on the pricing scheme chosen. There is not

a single "usage" for all pricing options. The existence of these repression effects invalidates the assumption that calling rate is independent of choice, especially if, as Southern Bell intends, the flat rate were to be increased.

Infosino was not unaware of these repression effects and their impact on his conclusions. He suggested that increases in the flat rate would probably cause some customers to avoid large bills by switching to measured options, and then repressing their usage. At the time of his writing, there had been no research on the repression effects of a change in class of service. Since then, Mitchell and Park (1981) have investigated the problem of repression. Their study examined the differences in repression for mandatory versus optional measured devices. Repression effects are much smaller for optional measured service because the customers switching to measured options are typically low usage customers and are able to maintain their calling rates with lower monthly bills. Again it is concluded that only high usage customers will repress calls.

Mitchell and Park (1981) present results which indicate that if the charges for flat rate service are increased, repression effects do occur. The existence of these repression effects suggests that Infosino's assumption that a customer's calling rate is independent of the class of service selected is not correct. In fact, customers modify their usage patterns depending on the pricing system under which they are billed.

As an aside, it is interesting to note that Infoeinc's model has been applied to data on Jupiter, Florida, which is the primary data set under study in this dissertation. Those results are presented in Garfinkel and Linhart (1980). A summary of the model's predictions are presented below.

CLASS OF SERVICE	PREDICTED SELECTIONS	ACTUAL SELECTIONS
Flat Rate	87.45%	88%
Standard Measured	7.22%	2%
Low-use Measured	5.33%	10%
Total	100.00%	100%

Once again, the model performs well at replicating the existing data. The model did have some trouble discriminating between the measured options.

In this study, aspects of each of the studies previously reviewed will be combined into a single framework. The decision tree framework will be employed, and a variation of logit analysis will be used to estimate the model. The variables in the model will include some estimate of the expected bill under each of the class of service choices, thus retaining some vestiges of the "bill-minimizing" behavior presented by Infoeinc, along with several economic and demographic variables to permit the assessment of the attractiveness of optional measured service to various groups of consumers.

Notes

[1]The author is grateful to Southern Bell for making these articles available.

[2]The linear probabilty model expresses estimated probabilities as linear functions of important variables or, $\hat{P} = \hat{\beta}'X$. In the logit model the estimated probabilities are of the form

$$\hat{P} = \frac{\exp\,[\hat{\beta}'X]}{1 + \exp\,[\hat{\beta}'X]}\,.$$

In the probit model the estimated probabilities are of the form

$$\hat{P} = (2\pi)^{-\frac{1}{2}} \int_{-\infty}^{\hat{\beta}'X} \exp -[Y^2/2]\; dy$$

[3]This point is discussed in detail in Chapter III of this dissertation

[4]The likelihood ratio index ρ^2 is given by $\rho^2 = \frac{1-\ln L_2}{\ln L_1}$ where L_2 is the value of the likelihood function at the maximum likelihood estimates, and L_1 is the value of the likelihood function when only the constant is used.

[5]If X and Y are random variables and $Y = \ln X$ is a normal random variable, then X is lognormally distributed. The parameters μ and σ^2 of the normal distribution Y also uniquely specify the lognormal random variable X.

[6]What is actually fit is the minimum of two lines, so a kink is present.

CHAPTER III

THE MODEL

The Theoretical Model

There have been two frameworks developed to model the decision to purchase access to the telephone system. The first models decisions of individual decision-making units in a consumer's surplus framework. The second approach models the decision in the context of simple utility maximization. Both of these frameworks may be extended to model the local rate choice decision, but the utility maximizing framework is selected for this study. Both of the procedures are outlined below, and some questions are raised as to the applicability of the consumer's surplus approach for modeling the access decision.

The consumer's surplus approach to the decision to purchase access has been used by Squire (1973), Mitchell (1978), and Taylor (1980). Their models link the demand for access to the demand for usage in the following fashion. First, the demand for calls is determined based on income, prices of other goods, and the utility function. After the demand for calls has been determined, and a usage price is set, the resulting consumer's surplus may be calculated. If the consumer's surplus exceeds the access price, access

is purchased. If the access price exceeds the resulting consumer's surplus, access is not purchased. The consumer's surplus concept used is the area to the left of the demand curve as in Taylor (1980).

There are some problems with this approach to the decision due mostly to the consumer's surplus concept. The first problem is that the area to the left of the demand curve, either compensated or uncompensated, may exceed income. Unless very great care is taken in the form of some very restrictive assumptions about the utility function,[1] the benefits from access will exceed the cost in most cases. Access cannot be purchased however, if the access price exceeds income. Thus, the decision rule is too naive.

In addition, it is not clear that consumer's surplus as it is traditionally defined is the proper measure in this case. Layard and Walters (1978) define consumer's surplus as the difference between the maximum amount a consumer is willing to pay for this current consumption of a good, and the amount actually paid. The key word in the definition is "current" since a consumer who does not possess a telephone has no current consumption. The concept that seems more appropriate in this instance is the compensating variation. This is defined by Layard and Walters as the maximum amount a consumer is willing to pay to purchase the option of buying any amount of a good at some given price. It should be noted that under certain

strict conditions (see note 1) the consumer's surplus measure and the compensating variation measure of the benefits of access are equal.

Artle and Averous (1973) and Rohlfs (1974) address the access decision in a utility maximizing framework. With slight modifications, this approach lends itself to the choice of class of service. Ultimately, the household chooses the utility maximizing pricing option.

To implement this method, the assumption is made that each household possesses an indirect utility function U which depends on household income M, the price of a composite good P_x, and the price parameters reflecting the choice of class of service made by the household. Each pricing option will be represented by three parameters, the access charge P_a, the usage charge or charge per call P_c, and A, the usage allowance. The consumer's indirect utility function may then be denoted by

$$U = U(P_a, P_c, A, M, P_x)$$

Now assume that each household chooses a pricing option from a set of options offered by the local telephone authority. Each pricing option or price vector P^i is composed of an access charge, a usage charge, and a calling allowance, thus $P^i = (P_a^i, P_c^i, A^i)$. If $P_c^i = 0$ and the calling allowance A^i is infinite or very large, the traditional flat rate pricing scheme is produced.[2] If each household is faced with m price vectors from which to choose, the household should choose the combination of

prices and allowances that permits the most utility to be obtained. Since income and the prices of other goods do not vary across choices, the utility function above may be simplified for the choice process

$$U = U\ (P_s,\ P_c,\ A).$$

If the maximum utility attainable given price vector P^i is denoted by U^i, the household's task is to choose the maximum maximorum, that is to select k so that

$$U^k = \max\ [U^1,\ U^2,\ .\ .\ .\ .\ ,\ U^m],$$

and then $P^k = (P_s^k,\ P_c^k,\ A^k)$ would be the pricing scheme selected.

The Estimable Model

The utility maximizing model of class of service choice can be very easily modified for use empirically. The problem will now be cast as an expected utility maximization problem. Let U^{ij} represent the perceived attractiveness of price vector P^i to the jth household. Let V^{ij} denote the actual attractiveness of price vector P^i to the jth household. Since the perceived attractiveness may not equal the actual attractiveness due to some lack of foresight, a stochastic component ε_{ij} is introduced to denote the errors between the two. Thus,

$$U^{ij} = V^{ij} + \varepsilon_{ij},$$

and the perceived attractiveness of each choice is a random variable. This is the classic random utility model (see Da Ganzo (1980) or Maddala (1982) for a discussion). Since random elements have been introduced, questions about choices must now be answered in terms of probabilities. In terms of the above, the probability that price vector P^k is chosen by household j is given by $Pr(P^k) =$

$$Pr[U^{k,j} > \max\ (U^{1,j}, \ldots, U^{k-1,j}, \ldots, U^{k+1,j}, \ldots, U^{m,j})]. \quad (1)$$

Multinomial Logit Model

The familiar multinomial logit model may be developed from the above if some assumptions about U^{ij} are made. Recall that $U^{ij} = V^{ij} + \varepsilon_{ij}$. Assume that the non-stochastic component V^{ij} is a linear function of variables and parameters so that

$$V^{ij} = \beta' X_{ij} + \alpha_i' Z_j. \quad (2)$$

In this representation, X_{ij} is a vector of choice-specific variables which shall henceforth be called attributes. Attributes, like the expected bill under each class of service, vary from choice to choice. The vector of parameters for these attributes, β, does not vary from choice to choice. In the above, Z_j is a vector of individual specific variables such as income, age of head of household, number of telephones, and others which do not vary across choices. They will be henceforth referred to as characteristics,

and they do not vary from choice to choice. The vector of parameters for these characteristics, α_i, does vary from choice to choice.

If additionally, the disturbance term ε_{ij} is assumed to have an extreme value distribution whose cumulative distribution function is

$$F(\varepsilon_{ij}) = \exp\,[-e^{-\varepsilon_{ij}}],$$

the solution of (1) yields selection probabilities of the familiar logit form. If P_{ij} denotes the probability that individual j makes choice i, then

$$P_{ij} = \frac{\exp\,[V^{ij}]}{\sum_{k=1}^{m} \exp\,[V^{kj}]}$$

where V^{ij} is defined as (2). If a normalization is applied, the probabilities may be written

$$P_{ij} = \frac{\exp\,[V^{ij}]}{1 + \sum_{k=1}^{m-1} \exp\,[V^{kj}]} \qquad i=1, \ldots , m-1 \qquad (3)$$

and $P_{im} = 1/D$, where D is the denominator in the expression above.

To examine the effects of changes in either attributes X_{ij} or characteristics Z_j, the probabilities above can be differentiated. If the probabilities are differentiated with respect to attributes, the following is obtained:

$$\frac{\partial P_{ij}}{\partial X_i} = \beta' P_{ij}\,(1-P_{ij})$$

Upon differentiating with respect to the characteristics, the following results:

$$\frac{\partial P_{ij}}{\partial Z_j} = P_{ij}[\alpha_i' - \sum_{k=1}^{m-1} \alpha_k' P_{kj}].$$

The parameters of the logit model presented above can be estimated by the method of maximum likelihood. The likelihood function is in this case of product of several probabilities. If Y_{ij} is a dummy variable taking on the value 1 if the jth household makes the ith selection, and zero otherwise, the likelihood function may be written

$$L = \prod_{j=1}^{n} P_{1j}^{Y_{1j}} \cdot P_{2j}^{Y_{2j}} \cdots P_{mj}^{Y_{mj}}.$$

The probabilities above are of the form given in (3) above. Differentiating the logarithm of the likelihood function leads to several nonlinear equations in α_i' and β. The values of α_i' and β which maximise the likelihood function may be found using an iterative procedure presented in Berndt, Hall, Hall, and Hausman (1974), and discussed in Maddala (1977).

This logit model may be used to estimate the rate choice problem, but there is a difficulty with using this formulation of the problem. One of the consequences of using logit analysis is that it implies the independence of irrelevant alternatives (IIA) The odds of making one

choice over another do not depend on the size or composition of the choice set. As one can easily observe, ratios of probabilities of the type given by (3) are not influenced by variables affecting the remaining probabilities.

The problem created by the IIA assumption is best illustrated by an example, the classic one being the "red bus-blue bus" example due to Debreu and discussed in Domencich and McFadden (1975). Suppose that an individual is selecting a mode of transportation. Assume that the individual is indifferent between choosing bus or automobile, and that the two buses are identical except for their color, one being red and the other being blue. Thus, $\Pr[R(R,A)]^3 = \Pr[B(B,A)] = \Pr[R(R,B)] = 1/2$, but $\Pr[R(R,B,A)] = \Pr[B(R,B,A)] = 1/4$, and $\Pr[A(R,B,A)] = 1/2$. The odds of choosing automobile over red bus depend on the presence or absence of the blue bus as an alternative. The difficulty is that the buses are very similar alternatives.

Logit models typically do not yield reasonable predictions when there is a large disparity in the degree of similarity between the alternatives. This may be the case in the price choice decision being analyzed. Each customer is faced with choosing between either the familiar, "old" flat rate, and the two "new" measured options. The newness of the measured options may, in the perceptions of the consumers, link them together. They may be viewed as being very similar since they are "new," but both are very

different from the "old" flat rate. This interaction should be accounted for, but this logit formulation cannot handle the problem.

There have recently been developments in decision modeling which relax the assumption of the independence of irrelevant alternatives. There are multinomial probit models, or MNP, and an entire class of "aspects" models which predict well when choice sets contain similar alternatives. These models will be reviewed in turn.

Multinomial Probit Models

Multinomial probit assumes that the error terms ε_{ij} are multivariate normally distributed. In contrast with multinomial logit, the variances need not be assumed constant, and covariance terms may be specified. As McFadden (1980) suggests, this augmented covariance structure eliminates the IIA assumption. The difficulty with MNP lies in its computational difficulty. MNP has been applied successfully in the three-choice case by Hausman and Wise (1978), using the method of maximum likelihood in conjunction with numerical approximation techniques. Due to the computational difficulties, MNP is not employed to estimate the class of service model.

Elimination by Aspect Models

Another way to take care of the similarity of the alternatives is the elimination by aspects (EBA) models

developed by Tversky (1972). These EBA models portray the choice process as one in which some aspect is selected upon, and then all alternatives without that aspect are disregarded. Then some new aspect is used as the basis to screen the remaining alternatives. Those alternatives without this new aspect are cast aside. This process continues covertly until only one alternative remains.

Consider the following case of a young man looking for a suit. He may covertly consider the aspects price, color and style, although not necessarily in that order. If the young man first decides to select on color, and considers blue suits, all suits that are not blue are immediately rejected. He next selects on either style or price. The EBA model implies nothing about the order in which the aspects are addressed. Aspects common to all of the alternatives in a choice set have no effect on the decision of the consumer.

Because of the large number of possible paths to an alternative in the EBA model, Tversky and Sattath (1979) examined a special case of the EBA model in which the alternatives can be represented by a tree-like graph. When this is possible the EBA model reduces to a simpler elimination-by-tree or EBT model. In the EBT model an individual selects a branch and then continues making choices down the branch until a decision has been made. For the rate choice problem the tree diagram looks like Figure 2. Again, the

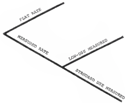

Figure 2. Tree Diagram for the Rate Choice Decision.

EBT model suggests nothing about where in the tree the process begins.

The EBT model, although still an EBA model, suggests another decision scheme which utilizes the ordering reflected by the tree. This model is referred to as the hierarchical elimination by aspects or HEBA model. The model simply uses the order which arises naturally from the tree structure. There are two levels of choice in the HEBA model. At the first level the individual decides whether to subscribe to a flat rate or a measured rate, and at the second level the individual selects the measured rate to which he will subscribe. To see how this model works, suppose that the (utility) values associated with different aspects of the rate choice decision are as follows.

LMS #1	V_1
LMS #2	V_2
Flat Rate	V_3
Measured Service	V_4

and assume that $\Sigma V_i = 1$. Then in the HEBA model,

$$\Pr\ (\text{LMS } \#1) = \Pr\ (\text{Measured Service is chosen}) \cdot \Pr\ (\text{LMS } \#1 \text{ is chosen} \mid \text{Measured})$$

$$= \frac{(V_1 + V_2 + V_4)}{(V_1 + V_2 + V_3 + V_4)} \cdot \frac{V_1}{(V_1 + V_2)}$$

The Nested Multinomial Logit Model

An easy computational method for estimating choice models with similar alternatives is the nested multinomial logit or NMNL procedure. The estimation of the NMNL models only requires the repeated use of multinomial logit, and thus NMNL is computationally feasible. To apply NMNL to the class of service problem, one must first examine the choice between the low-use measured option and the standard-use measured option. These selection probabilities and the implied α's and β's can be estimated using MNL which has been outlined previously.

To illustrate how the NMNL procedure accounts for the similarity between the two measured options, one may develop the NMNL procedure from the MNL models previously discussed. Let V_1 denote the linear combination of variables and parameters affecting the probability of the selection of the flat rate, and let V_{21} and V_{22} denote the corresponding linear combinations for the selection of the low-use measured option and the standard-use measured option, respectively. If the MNL procedure were used to estimate the selection probabilities, they would have the familiar form

$$\Pr(\text{Flat rate}) = \frac{\exp[V_1]}{\exp[V_1] + \exp[V_{21}] + \exp[V_{22}]} \qquad (4)$$

is the case of the flat rate, for example. The NMNL procedure attempts to take account of the similarity in the

two measured options by combining their impact into a single new variable called the inclusive value. This inclusive value may be denoted by I and defined:

$$I = \log(\exp[V_{21}] + \exp[V_{22}]). \tag{5}$$

The inclusive value depends on parameters that must be estimated, namely the α's and β's in V_{21} and V_{22}. These parameters may be estimated using MNL, and only information on the customers who chose measured service. The probabilities in this first stage of estimation may be written:

$$\Pr(\text{Low-use}|\text{Measured}) = \frac{\exp[V_{21}]}{\exp[V_{21}] + \exp[V_{22}]} \quad .$$

The probability is a conditional probability because the estimation is performed for only those individuals choosing measured service. After the parameters have been estimated using only information on those individuals who chose measured service, the inclusive value may be generated for all individuals, even those who selected the flat rate. Thus, the inclusive value is included as a variable in the second stage, and by substituting (5) into (4) an algebraically equivalent expression is

$$\Pr(\text{Flat rate}) = \frac{\exp[V_1]}{\exp[V_1] + \exp[I]} \tag{6}$$

In order to allow the measured branch to be discounted, the inclusive value is assigned a coefficient of $1-\sigma$ in the second stage. The above expression becomes

$$\Pr(\text{Flat rate}) = \frac{\exp[V_1]}{\exp[V_1] + \exp[(1-\sigma)I]} \quad ,$$

or, in the form in which the estimation occurred

$$\Pr(\text{Flat rate}) = \frac{\exp[V_1 - (1-\sigma)I]}{\exp[V_1 - (1-\sigma)I] + 1} \; . \qquad (7)$$

The value of σ allows the contributions of the measured options to be discounted if customers do not view them as separate choices. For example, the two polar cases are σ=0 and σ=1. If σ=1 for instance, the above expression becomes

$$\Pr(\text{Flat rate}) = \frac{\exp[V_1]}{\exp[V_1] + 1} \; ;$$

this is exactly the form the probabilities would take in a two choice MNL model. In this case the two measured options have been "fully" discounted in the sense that consumers are either choosing flat or measured, and have been unable to discriminate between the two measured options. At the other extreme σ=0 implying that consumers view the measured options distinctly. In this case equation (7) becomes

$$\Pr(\text{Flat rate}) = \frac{\exp[V_1]}{\exp[V_1] + \exp[V_{21}] + \exp[V_{22}]}$$

which is actually equation (4). Consumers view the measured options distinctly so that no discounting occurs and MNL models could be justified.

The coefficient of the inclusive value, $1-\sigma$, is an index of the similarity between the low-use measured service option and the standard measured service option. As $1-\sigma$ increases, or σ gets smaller, the options are viewed as being less similar. As σ increases, or $1-\sigma$ gets small, the choices are being viewed by households much less distinctly.

The NMNL formulation allows the class of service choice problem to be analyzed in a decision tree framework. There are many reasons why it is appropriate to estimate such a model here. First, the NMNL procedure is computationally easy, involving only repeated application of the MNL estimation procedure outlined previously. McFadden argues that numerical experiments indicate that NMNL models give nearly identical fits as HEBA models which allow the use of a decision tree framework. McFadden (1978) has shown that if the coefficient of the inclusive value lies between 0 and 1, the NMNL is consistent with random utility maximization, making it again well founded theoretically.

Additionally, it will be very useful to examine the magnitude of σ, the approximate correlation[4] between the two measured options. This coefficient will give an indication as to how customers view these options, which may provide

information on whether measured service has been successfully marketed. If the coefficient indicates that the choices are viewed as being quite similar, perhaps measured service is not well understood by the public, at least not to a degree which permits discrimination of different measured options. Furthermore, the NMNL approach will permit concentration on the measured/flat decision which is primary for predicting revenues. Bills do not differ as much between measured options as they do between either measured option and the flat rate. Thus, revenues will be much more greatly effected by the measured/flat decision. It is apparent that the NMNL has much to commend it as the technique used to evaluate the class of service decision.

Important Variables

In order to discuss the impact of various attributes and characteristics used in the model, one may consider each stage of the decision individually. The first decision is whether to choose the flat option or a measured option. Several economic, demographic and attitudinal variables may explain this decision. The next choice made by households electing a measured option is whether to select the low-use measured option or the standard-use measured option. This decision may be much more difficult to model than the first one. Some very basic hypotheses about how variables affect the selection probabilities will be presented.

Before beginning, an important point should be made. As the names "low-use" and "standard-use" imply, the choice of class of service is expected to be related to the calling rate. Households making few calls should frequently select the low use option. Households making many calls should most frequently select the flat rate option, and the standard use measured option should appeal to households making moderate quantities of calls. These simple rules for choosing class of service certainly do not hold absolutely, but they represent an initial approximation. The reason this relationship between choice of class of service and calling rates is important is simple; there has been no previous empirical research using individual choice theory to model the class of service decision.

Thus, there is no empirical basis for determining which variables belong in the model, and for determining their expected direction of impact on the selection probabilities. However, research has been done on the impact of various socioeconomic variables on the calling rate. It is hoped that by using the relationship between the socioeconomic variables and the calling rate, and by using the relationship between the calling rate and the rate choice that some predictions may be made as to how socioeconomic variables affect the selection probabilities. By exploiting this connection, one can speculate about the impact of many variables.

The first and most important decision the household faces is the choice between measured local service, and the traditional flat rate pricing of local service. Economic theory, along with the results of previous research [most notably that of Perl (1975, 1978), Mahan (1979), Infosino (1979), and Brandon (1981)] will be used to predict the influence of various economic and demographic variables on the selection probabilities.

Economic theory will be used in order to assess the impact of variables on the probabilities of choosing the options. Again, there has been no research done on how various variables effect the choice of class of service. Economic theory will be relied upon to predict the influence of these variables on the quantity of calls made by a household. This relationship will in turn be used to predict the influence of the variables on the choice of class of service

An important variable used in the model is the expected bill for local calls under both measured and flat rates. This variable is expected to exert a negative effect on the probability of an option's selection. If the expected bill under an option increases, that pricing option is less likely to be chosen.

Economic theory suggests that income should be an important variable in the model. Several studies of local residential demand for telephone calls indicate that the income elasticity of demand for calls is positive. This

positive income elasticity suggests that increases in income should increase the probability of the flat rate being selected, because the flat rate permits increased calling without increased expenditures. Brandon (1981) found a positive relationship between income and the median number of calls. Total conversation time, however, was found to be highest for the $15,000 to $19,999 group. Since billing is related to total conversation time, Brandon's results suggest that income's relation to the choice of rate may be less clear than previously suggested.

Economic theory suggests that price should exert a negative influence on the quantity of calls demanded. There was not sufficient variation in the price variables to include them in the model, although the expected bill in a sense represents the price of each option.

Economic theory also says that the quantity demanded is related to the prices of substitutes. The price of substitute calls is lower for some customers than for others. Some customers may easily make calls from their worksites, while other customers may find this alternative to residential calling difficult or impossible. Customers working in office surroundings, such as professors, secretaries, and business people may be able to originate personal calls from the worksite, and thus avoid payment. These customers may easily shift the origin of some of their residential local calls to the worksite. Other customers not employed in office oriented occupations such

as factory workers and manual laborers do not have the option of shifting some calls to the worksite. These workers must rely more heavily on the household for their local calling needs. Thus, those customers working in and around offices will find it easier to avoid large bills by switching to measured options without sacrificing calls, because many calls can be made from the office.

Other things equal, the number of people in a household should exert a positive effect on the quantity of calls, thereby increasing the probability of the selection of the flat rate. This relationship is suggested by Mahan (1979), and also noted by Brandon (1981), who finds that the age and sex distribution of individuals within a household has an important effect on the calling rate. Specifically, Brandon noted that the largest positive influence on the calling rate could be attributed to the presence of young teenage girls. Calling rates tended to be higher for households with teenagers of either sex present.

Brandon (1981) has also found lower calling rates for two age groups of the head of the household: 55 to 64, and 65 or over. Mahan's (1979) study indicates that these age groups are more likely to have a telephone. The results of these studies suggest that more elderly households possess telephones, but use them less frequently. Perl's hypothesis that increased age implies decreased mobility and increased dependence on telephone access seems supported

by these results. Given these two tendencies it then seems logical that the increased age of the head of the household should increase the probability of measured service being selected.

Brandon's study also indicated that black households tend to have much higher calling rates than whites. This suggests that blacks will be more likely to purchase the flat rate option than whites, other variables equal.

Many other variables may be used to estimate the flat versus measured choice. There are various measures of neighborhood tenure which may exert a positive effect on the calling rates. The numbers of years that a household has remained in a neighborhood probably increases the quantity of calls and the probability of choosing the flat rate. Home ownership may indicate how long a household intends to remain in a neighborhood. Households intending to remain in neighborhoods for long periods of time have vested interests in making contacts, and generally learning the neighborhood. This variable may also exert a positive influence on the calling rate. Other variables--like employment category, educational level of the head of household and many others--have been used with varying success in other models.

The second decision for those households initially choosing measured is whether to choose the low-use measured option, or the standard-use measured option. The variables discussed previously should be important in determining

these selection probabilities as well. Variables indicative of high calling rates will exert positive effects on the probability of selection of the standard-use measured option. Variables indicative of low calling rates will positively influence the selection of the low-use option.

In summary, no individual class of service choice model has been estimated prior to this study. There are no previous empirical or theoretical works upon which hypotheses about variables may be based. Economic theory has little to say about which variables affect a multi-part price choice. However, the connection through the demand for calls provides a basis for evaluating the impact of various variables on the choice of class of service. One of the purposes of this study is to explore the relations between key variables and selection probabilities.

Notes

[1]For the consumer surplus measure to be finite and less than income, and in order to make the decisions consistent with a utility maximizing framework, some very strict conditions are necessary. First, if the quantity of calls is measured on the horizontal axis, the indifference curves need to be vertically parallel. This assumption implies that the quantity of calls is unaffected by changes in income. Studies by Dobell et al. (1970), NYT (1976), and SNET (1977) have found small but non-zero income elasticities. The indifference curves must also cross the vertical axis. In this case, the consumer surplus and the compensating variation measures are equivalent.

[2]When the marginal price is zero for additional calls, there is still a time cost. The time related cost component of the price of a call may result for several reasons. It may partially be due to opportunity cost factors related to foregone earnings or foregone household consumption. This interpretation is somewhat tempered by the fact that possibly several individuals in the household have access to the telephone, and some customers, like children, may have to forego little in order to use the telephone. This component may also refer to the excludability of telephone use. If one individual is using the telephone, no others may use the phone. In addition, no incoming calls may be received. All of these factors relate cost to length of call.

[3]In this notation, $Pr[R\{R,A\}]$ means the probability that a red bus is chosen from a set consisting of a red bus and an automobile.

[4]McFadden has informed my chairman, Professor Maddala, that he was unable to prove that σ is the correlation. By numerical methods he did find the relation, $\sigma < \rho < \sigma + 0.045$, thus σ is approximately equal to the correlation coefficient.

CHAPTER IV

RESULTS

In this chapter the empirical results are presented along with some discussion of their interpretation. In Table 1 the results of the estimation of the nested logit model are presented. In Table 2 the net impacts of variables on the flat versus measured decision are given. This table is necessary because a variable may influence the flat versus measured choice directly, or through the inclusive value. Exactly how this occurs will be demonstrated in a later section. Tables 3 and 4 present the results of estimating 2-choice and 3-choice logit models respectively. They are presented for comparison with the results of the nested logit estimation in Table 1. Finally, Table 5 gives a summary of selected elasticities based on parameter estimates given in Tables 1, 3 and 4. The results will now be discussed in some detail.

The Low-Use Versus Standard-Use Choice

The estimated coefficients in the low-use measured versus standard-use measured decision are presented in column one of Table 1. The logarithm of the odds of choosing low-use measured over standard-use measured may be

TABLE 1

RESULTS OF THE NESTED LOGIT ESTIMATION

VARIABLE	EQUATION LOW-USE VS. STANDARD USE	EQUATION FLAT VS. MEASURED
Estimated bill (low-standard in equation 1 and flat-standard in equation 2)	-0.822 (0.242)*	-0.006 (0.012) [0.012]**
Intercept	0.078 (0.758)	-2.286 (0.683) [0.793]
Number of years in present home	0.185 (0.058)	0.201 (0.050) [0.067]
Number of telephones		0.880 (0.217) [0.220]
Estimated average length of call	-0.058 (0.045)	0.032 (0.036) [0.042]
Dummy variable = 1 if person feels he/she is low caller		-0.818 (0.326) [0.364]
Dummy variable = 1 if some social activity by household member	-0.395 (0.397)	
Age of household head	0.133 (0.092)	0.056 (0.085) [0.112]
Dummy variable = 1 if person is professional or technical worker		0.067 (0.379) [0.472]
Dummy variable = 1 if person is manager, official, or proprietor	0.202 (0.467)	0.624 (0.421) [0.587]
Dummy variable = 1 if person is sales or clerical worker	0.897 (0.574)	0.049 (0.491) [0.658]

Continued

TABLE I

CONTINUED

VARIABLE	EQUATION	
	LOW-USE VS. STANDARD USE	FLAT VS. MEASURED
Dummy variable = 1 if person is craft worker or foreman	1.442 (0.618)	0.469 (0.325) [0.613]
Dummy variable = 1 if person is semi-skilled worker	-2.211 (0.923)	1.147 (0.342) [0.955]
Dummy variable = 1 if person is service worker	-1.338 (0.719)	-0.932 (0.645) [0.693]
Income category	-0.042 (0.017)	-0.022 (0.013) [0.016]
Interaction (high educational level x low local calls)	0.881 (0.380)	
Inclusive value		-0.570 (0.280) [0.413]
- log likelihood	106.315	131.995

*Figures in parentheses are standard errors.

**Figures in brackets are the adjusted standard errors. For discussion refer to note 1.

TABLE 2

NET IMPACT OF VARIABLES ON THE FLAT VS. MEASURED CHOICE

VARIABLE	ADJUSTED COEFFICIENT
Intercept	-2.322
Number of years in present home	0.117
Number of telephones	0.880
Estimated average length of call	0.058
Dummy variable = 1 if person feels he/she is low caller	-0.818
Dummy variable = 1 if some social activity by household member	0.180
Age of household head	-0.004
Dummy variable = 1 if person is professional or technical worker	0.067
Dummy variable = 1 if person is manager, official, or proprietor	0.532
Dummy variable = 1 if person is sales or clerical worker	-0.360
Dummy variable = 1 if person is craft worker or foreman	0.211
Dummy variable = 1 if person is semi-skilled worker	2.155
Dummy variable = 1 if person is service worker	-0.322
Income category	-0.002
Interaction (high educational level x low local calls)	-0.402

TABLE 3

RESULTS OF THE 2-CHOICE LOGIT ESTIMATION (σ=1)

VARIABLE	FLAT VS. MEASURED
Estimated bill	-0.022* (0.012)
Intercept	-2.462 (0.681)
Number of years in present home	0.134 (0.039)
Number of telephones	0.837 (0.216)
Estimated average length of call	0.037 (0.033)
Dummy variable = 1 if person feels he/she is low caller	-1.000 (0.297)
Age of household head	0.002 (0.079)
Dummy variable = 1 if person is professional or technical worker	0.051 (0.376)
Dummy variable = 1 if person is manager, official, or proprietor	0.364 (0.396)
Dummy variable = 1 if person is sales or clerical worker	-0.491 (0.411)
Dummy variable = 1 if person is craft worker or foreman	1.460 (0.458)
Dummy variable = 1 if person is semi-skilled worker	0.949 (0.971)
Dummy variable = 1 if person is service worker	-0.695 (0.641)

Continued

TABLE 3

CONTINUED

VARIABLE	FLAT VS. MEASURED
Income category	-0.010 (0.012)
- log likelihood	132.007

*Figures in parentheses are standard errors.

TABLE 4

RESULTS OF THE 3-CHOICE LOGIT ESTIMATION (σ=0)

VARIABLE	EQUATION: LOW-USE VS. STANDARD USE	EQUATION: FLAT VS. STANDARD USE
Estimated bill	0.002 (0.013)*	0.002 (0.013)
Intercept	1.462 (0.742)	2.699 (0.812)
Number of years in present home	-0.065 (0.043)	-0.238 (0.052)
Number of telephones	-0.787 (0.208)	-0.851 (0.261)
Estimated average length of call	-0.119 (0.036)	-0.031 (0.038)
Dummy variable = 1 if person feels he/she is low caller	1.485 (0.315)	0.659 (0.367)
Dummy variable = 1 if some social activity by household member	0.046 (0.082)	-0.040 (0.091)
Age of household head	-0.025 (0.381)	0.239 (0.424)
Dummy variable = 1 if person is professional or technical worker	-0.193 (0.414)	-0.501 (0.476)
Dummy variable = 1 if person is manager, official, or proprietor	0.796 (0.466)	0.000 (0.465)
Dummy variable = 1 if person is sales or clerical worker	-1.986 (0.719)	-0.884 (0.495)
- log likelihood	307.976	

*Figures in parentheses are standard errors

TABLE 5

SELECTED ELASTICITY ESTIMATES CALCULATED AT THE MEANS

VARIABLE	ESTIMATION METHOD		
	NMNL	2-CHOICE MNL	3-CHOICE MNL
Estimated bill	-0.021	-0.035	0.003*
Number of years in present home	0.098	0.113	0.105
Number of telephones	0.226	0.215	-0.027
Dummy variable = 1 if person feels he/she is low caller	-0.071	-0.087	0.083
Income category	-0.007	-0.034*	**

*These elasticities were calculated using coefficients whose t-ratios were less than one in absolute value.

**No coefficient for income category was estimated using 3-choice logit analysis due to the inability of the maximum likelihood estimation technique to converge for a large number of parameters.

interpreted as a linear function of these variables. A positive sign on a coefficient indicates that an increase in the corresponding variable will lead to an increase in the likelihood that the customer subscribes to the low-use option. A negative sign on a coefficient implies the opposite. Each variable will be discussed in turn.

The first estimated coefficient is that of the estimated bill. The estimated bill was determined by using the customer's perceptions of his average number of calls per day, and his average call length. These numbers were then used to construct an approximate bill under each of the three pricing schemes. The estimated bill was used to represent customer perceptions of each option, or the relative attractiveness of each option to a customer. In a sense the idea of using the customer's perceived calling patterns rather than actual calling patterns may make this variable a more useful measure. Several studies have found that customers do not tend to be very accurate in their estimation of their calling frequency. Most customers tend to overestimate their telephone usage. However, as far as selecting a pricing structure, the perceived amount of calling rather than the actual seems to be the appropriate measure.

As a consequence of normalizations required by the estimation, the variable is actually the difference between the customer's perceived bill under the low-use measured option, and the perceived bill under the standard-use

measured option. Due to some special problems the estimation of this coefficient creates, it will be discussed in a later section of this chapter.

The next variable to be discussed is the number of years in the present home. This variable has a positive impact on the probability of the low-use measured option being selected. Although the connection between calling rates and numbers of years in present home was established in the previous chapter, the positive sign of this coefficient may not be a contradiction. For only those customers choosing measured options, an increase in the number of years in the home may lead to diminished calling rates, and thus increase the probability of the selection of the low-use option. Those customers selecting measured options typically generate lower calling volumes than customers choosing the flat rate option. Those customers have fewer people in the household, fewer telephones, and are generally employed in occupations which permit substitution for local telephone service. In this group an increase in the number of years in the present home may lead to fewer individuals in the household, and eventually, lower calling rates. Thus, for those households choosing measured options, an increase in the number of years in the home may decrease calling rates, and increase the probability of the selection of the low-use measured option

The estimated average length of a phone call seems to provide useful information about the selection of

class of service. As is to be expected, those individuals who believe that their calls are long are less likely to choose the low-use measured option. The estimated length of call provides some information as to an individual's perception of himself as a caller.

The next variable to be discussed is a dummy variable which has the value one if a member of the household is engaged in some social activity. As anticipated, this social activity may lead to increased telephone usage, and a decreased probability of choosing the low-use option. This expectation seems realized since the estimated coefficient has a negative sign.

The next variable is the age of the head of the household. Increases in this variable are seen to have the effect of increasing the probability of the low-use option being chosen. For many of the same reasons that were discussed under the effects of the number of years in the present home, the increased age should lead to decreased calls, and an increased probability of the low-use option being selected.

Before proceeding to the next six variables, a preface may be useful. The next six variables to be discussed are all dummy variables for various employment categories. At first glance their inclusion in a class of service choice model may not seem justified. This is not the case, however, because economic theory suggests that the demand

function for a commodity depends on the price of substitutes, among other things. This may be the case with the demand for local telephone calls. Various occupations, specifically office-type jobs, provide much greater possibilities for substituting local calls that normally would be made in the household. Individuals in occupational categories enjoying the option of free local telephone service may exercise this option, and subsequently reduce the number of local calls originating in the household. This implies that individuals in occupations with business telephones may be more likely to choose a measured option. Individuals in occupations without access to business telephone service may be expected to lean toward a flat rate service, other factors being held equal. This substitution just described certainly occurs now in the market for long distance calls, which are frequently made from the office. The evidence about to be presented suggests that to a degree the same phenomenon occurs in the market for local calls.

The first variable to be discussed from the set of occupational dummies takes on the value one if the person is a manager, an official, or a proprietor. As suggested previously, these individuals may be able to make considerable local calls from their work sites, and thus need not call from the home. Such a circumstance permits subscription to the relatively inexpensive low-use measured option. This is indicated by the positive sign of the estimated coefficient of this variable.

The next occupational dummy has the value one if the individual is a sales or clerical worker. Once again due to the possibilities for substitution at work, these individuals are more likely to subscribe to the low-use measured option. The positive sign on the estimated coefficient reflects the anticipated effect.

The next dummy variable has the value one if the individual is a craft worker or foreman. At first glance this coefficient should have a negative sign; however, some occupations in this category are more office oriented than others, and the actual mix of occupations is unknown. The possibility that the office oriented occupations occurred with greater frequency could account for this result.

The next occupational dummy is that of semi-skilled workers. This group is not office oriented, and one would not anticipate that this group had substantial substitution possibilities. This expectation is reflected in the negative sign of the estimated coefficient.

The final occupational dummy variable is for the service worker category. This group also is not generally office oriented, and must thus place the local calls from the household. The estimated negative sign of the coefficient of this variable suggests that this is indeed the case.

The negative sign of the estimated coefficient of the income category variables indicates that increases in

income decrease the probability of the low-use measured option being selected. Once again, due to the optional nature of the experiment, measured service was selected if it was less expensive. The low-use measured option has the potential to be the least expensive choice of the three rates, so it is not surprising that increases in income diminish its selection probability.

The final variable included in the equation is an interaction variable which includes those individuals who are highly educated low callers. These individuals may have the easiest time understanding measured service, and measured service may afford them more benefits than moderate or heavy callers. The result that membership in this group greatly increases the probability of the low-use measured option being selected is not surprising.

The Flat Versus Measured Choice

The estimated coefficients in the flat versus measured decision are presented in column two of Table 1. In Table 2 the adjusted coefficients are given. These adjustments account for the fact that a change in a variable in the first stage, or the low-use versus standard-use decision, will affect the selection probabilities in the second stage, or flat versus measured decision. The logarithm of the odds of choosing flat over measured is a linear function of the variables in Table 2.

The following discussion will show how the influence of characteristics may occur through the inclusive value. As was indicated in Chapter III, the probability of selecting the flat rate in stage two is given by

$$\Pr(\text{Flat rate}) = \frac{\exp[V_1 - (1-\sigma)I]}{\exp[V_1 - (1-\sigma)I] + 1},$$

where $I = \log\{\exp[V_{21}] + \exp[V_{22}]\}$. The odds in favor of choosing the flat rate are then

$$\frac{\Pr(\text{Flat rate})}{1-\Pr(\text{Flat rate})} = \exp[V_1 - (1-\sigma)I].$$

The natural logarithm of the odds is thus

$$\text{logn (odds)} = V_1 - (1-\sigma)I.$$

The above expression may be differentiated with respect to the characteristics Z_j to yield

$$\frac{\partial \text{logn(odds)}}{\partial Z_j} = \frac{\partial V_1}{\partial Z_j} - (1-\sigma)\,\frac{\exp[V_{21}]\frac{\partial V_{21}}{\partial Z_j} + \exp[V_{22}]\frac{\partial V_{22}}{\partial Z_j}}{\exp[V_{21}] + \exp[V_{22}]},$$

but $V_{22} = 0$ due to a normalization necessary in order to identify the parameters. Thus, the above can be written

$$\frac{\partial \text{logn(odds)}}{\partial Z_j} = \frac{\partial V_1}{\partial Z_j} - (1-\sigma)\frac{\partial V_{21}}{\partial Z_j}(\Pr(\text{Low-use measured}|\text{Measured})),$$

where $\frac{\partial V_1}{\partial Z_j}$ represents the estimated coefficient of some characteristic in the flat versus measured column of Table 1, and $\frac{\partial V_{21}}{\partial Z_j}$ is the estimated coefficient of the same characteristic, if one exists, presented in the low-use versus standard-use column of Table 1. The results of these calculations are given in Table 2. With this knowledge the impacts of the explanatory variables can be discussed.

The first variable is the difference between the bill under the flat rate option and the standard-use measured option. This coefficient will be discussed in a later section of this chapter.

The next variable to be examined is the number of years in the present home. The coefficient of this variable is significant, and adjusted coefficient indicates a positive effect on the likelihood of choosing the flat rate, which is the expected direction of influence. The longer a family remains in one location, the more interaction occurs between the family and the neighborhood. This interaction is both social and business related. Households remaining in areas longer have more people to call, and thus for those households a greater advantage results from subscribing to the flat rate.

The number of telephones in a household seems to exert a significant positive influence on the probability of the

flat rate being chosen. This direction of impact seems correct, and may be substantiated by either of two arguments, both of which suggest that larger numbers of telephones are related to larger numbers of calls. Originally, all customers participating in the study were subscribing to flat rate service. Consider a customer's decision to purchase a second telephone. The cost of making a telephone call must include some valuation of the individual's time to get to the telephone, though the marginal price of a telephone call is zero under the flat rate pricing scheme. The cost of answering the telephone should also include this time cost. An increase in the number of telephones will decrease the time spent traveling to the telephone. If this time saving is valued more than the price of an additional telephone, the customer is better off with additional telephones. The cost of not having additional phones is directly related to telephone usage, since more trips are required. Thus, customers with several telephones must on average be more frequent users of the telephone than customers with fewer telephones. The direction of the effect may also be defended on the grounds of privacy. Individuals may desire separate lines for reasons of confidentiality. These individuals perhaps move in different social circles, and thus the number of potential calls is greatly multiplied.

The average length of a call estimated by the subscriber has a significant positive effect on the probability of choosing the flat rate. One might suspect that

those individuals who believe their average call length is large are heavy callers. This plausible hypothesis is substantiated by the empirical results.

The next variable is a dummy variable which equals one if the customer feels he is a low caller. The coefficient of this dummy variable is negative and significant. This is precisely to be expected since low callers may benefit from choosing one of the measured options instead of the flat rate.

The next variable included via the inclusive value is a dummy variable which equals one if some household member is involved in some social activity such as club membership or church groups. Engaging in social activities probably increases telephone use. Increased telephone usage should lead to an increased likelihood of choosing the flat rate. This suggestion is borne out by the positive sign of the adjusted coefficient for this variable.

The next variable to be examined is the age of the household head. The estimated coefficient is positive, but not significant, and the adjusted coefficient is negative. The direction of impact of this variable cannot be ascertained. As age increases, more social contacts are made thereby suggesting they should make more calls increasing the probability of choosing the flat rate. However, as previously suggested, the work of Brandon and Mahan indicates that the elderly make fewer calls, which thus

increases the probability of their choosing a measured option. The results of the analysis of the Jupiter data are inconclusive.

The first coefficient estimated for the group of employment dummies is that for the "professional or technical worker group." Included in this category are occupations like engineer, scientist, doctor, teacher, and clergy. These occupations are office oriented, and thus one might expect the estimated coefficient to be negative. It is positive, although not significant, as is the adjusted coefficient. It is not possible to determine the frequencies with which various occupations are present in the group. The possibilities for substituting local calls is not the same for all occupations within a group, and the results could have been influenced by a disproportionate representation of some occupation with relatively little office substitution possibilities.

Another possible explanation of this employment group result may lie in the fact that the opportunity cost of calling from the office may be very large for some occupations. For example, lawyers and doctors certainly have telephones available for use during their workdays, but the cost of their use in terms of foregone earnings may be too large. This certainly does not preclude the use of secretaries by doctors and lawyers for some local calls, however some calls may be of a type that must be made by the doctor or lawyer--calling one's spouse, for example. The

composition of the employment category and the foregone earnings may account for the estimated coefficient.

The next occupational dummy variable is for the "manager, official, or proprietor" group. Included in this category are occupations like executives, store managers, farm owner or manager, postmaster, and other supervisory personnel. The positive sign for this coefficient is unexpected, but this category may include many self-employed people whose residential and commercial telephone use may be combined to a degree. This could account for the fact that workers in this category had a greater tendency to select the flat rate.

The next category to be examined is that of "sales or clerical workers." Included in this category are secretaries, bookkeepers, bank tellers, cashiers, postal workers, telephone operators, and sales people. One might expect that this group has some possibility for substituting local calls at the worksite. This tendency is reflected in the negative adjusted coefficient for this variable.

The next coefficient estimated for the group of employment dummies is that of the "craft worker or foreman" group. Included in this employment group are carpenters, plumbers, engravers, line installers and repairers, radio and TV repairers, mechanics, bakers, upholsterers, and other similar occupations. Most of the occupations listed above are not office oriented, and thus do not present possibilities for the substitution of local calls. The fact that the

bulk of local calls must originate in the household is reflected in the positive sign of the adjusted coefficient of the "craft worker or foreman" employment dummy.

The next employment category is the "semi-skilled worker" group. Occupations like deliveryman, brakeman, factory worker, welder, parking attendant, textile weaver, mineworker, and others are included in this group. These occupations are also in general not office oriented, and thus customers in these occupations may have larger home calling burdens. These large home calling burdens should be reflected by an increased probability of choosing the flat rate. This hypothesis is again substantiated by the positive sign of the adjusted coefficient of this income group.

The final employment dummy used is for individuals in the "service-worker" category. Included in this group are barbers, police officers, practical nurses, airline flight attendants, janitors, cooks, housekeepers, and others. The adjusted coefficient of this variable is negative. The negative sign may be justified because many of these occupations provide opportunities for free local telephone use. Those individuals using business phones for personal calls may be able to save by choosing one of the measured options.

The next coefficient is that of income category. The estimated coefficient is negative, and so is the adjusted coefficient. It seems that over the range of incomes in the sample, increase in income primarily affect

measured users. Additional income causes these individuals to switch from low-use measured to standard-use measured. The flat versus measured choice is unaffected, and this is reflected in the very low adjusted coefficient.

Another variable which has an effect through the inclusive value is a dummy interaction variable. This variable is the product of high educational level and low local calls. Membership in this group should predispose one toward either of the measured options. This is equivalent to saying that membership in the group should decrease the probability of the flat rate being selected. This is again evident in the negative sign of the adjusted coefficient estimate.

The final coefficient estimated is that of the inclusive value. The value of the estimated coefficient, -0.570 corresponds to a value of σ equal to 0.430, which approximately measures the correlation between the two measured options. This value provides much useful information. First, the fact that the value lies in the unit interval indicates that the nested model estimated is consistent with random utility maximization, and thus firmly theoretically based. Second, the fact that the correlation is large indicates that customers are not easily discriminating the two measured options, and that customers view the options as being very similar. The inability of the customers to distinguish the measured options can be explained in several ways. The measured

options may not have been successfully marketed or sold to the public, due to insufficient effort by the marketing department of the telephone company, or it may be simply that the public finds measured service a difficult subject to comprehend.

The impact of the marketing of measured service or its acceptance rate may not be as large as the effect of the expense of the flat rate. In the data analyzed herein the flat rate remained at its previous, relatively low, level. Thus, the cost of not understanding measured service, or the flat rate price, was really not very great. It seems logical that when the flat rate is increased, the cost of not understanding measured service will increase, and customers will begin to seriously examine the measured options. After the flat rate is increased, the price incentive to investigate measured service will have been established. The perceived similarity of the measured options should diminish under the condition of increasing flat rates.

The Effect of Increasing the Flat Rate

It is Southern Bell's intention to increase the flat rate when measured service is implemented for general residential use. In this section some predictions based on the results in the first two sections will be made concerning the impact of this increase on the subscription or "take rate" of flat rate pricing. Following this discussion an analysis of customer decisions based on the break points will be presented.

The coefficient of the estimated bill is critical in determining what effect an increase in the flat rate will have on the number of customers choosing an option. As was noted in Chapter III, there is a single estimated coefficient for each attribute, thus there should be a single estimate of the coefficient of the estimated bill. This is not the case. The nested logit procedure yields multiple estimates of the coefficients of attributes. The "estimated bill" coefficient in the first stage, or β_1, was -0.822. The second stage estimate was $\beta_2 = -0.006$. These estimates must be resolved if the model is to used for prediction.

Three possible solutions to the problem of multiple estimates will be discussed. First, the model could be jointly estimated by full information maximum likelihood, or FIML, which would yield single estimates for the coefficients of attributes. Although a statistically superior solution, FIML requires more sophisticated programming procedures since the estimation cannot be achieved by repeated use of MNL techniques.

A single estimate for the "estimated bill" coefficient may also be obtained from 3-choice logit estimation. However, as Table 4 indicates, the coefficient is not significant and has the wrong sign. The 3-choice model implicitly assumes that all choices are independent which clearly is not the case in the class of service choice problem.

The final solution, and the one employed in this dissertation, is to combine the two estimates $\hat{\beta}_1$ and $\hat{\beta}_2$ into a single estimate $\hat{\beta}$ by finding the variance-minimizing linear combination of $\hat{\beta}_1$ and $\hat{\beta}_2$. A linear combination is chosen so that the estimator $\hat{\beta}$ will be consistent. Thus, the task is to choose a new estimate $\hat{\beta}$, so that,

$$\hat{\beta} = \lambda\hat{\beta}_1 + (1-\lambda)\hat{\beta}_2.$$

The variance of $\hat{\beta}$ is then

$$\mathrm{var}(\hat{\beta}) = \lambda^2\sigma_1^2 + (1-\lambda)^2\sigma_2^2 + 2\lambda(1-\lambda)\sigma_{12} ,$$

where σ_1^2 is the variance of $\hat{\beta}_1$, σ_2^2 is the variance of $\hat{\beta}_2$, and σ_{12} is covariance between $\hat{\beta}_1$ and $\hat{\beta}_2$. Minimization of the expression leads to a solution for λ in terms of σ_1^2, σ_2^2, and σ_{12}. Application of this procedure implies that $\hat{\beta} = -0.013$.

In order to assess the impact of increases in the flat rate one must examine the derivative of the probability of choosing the flat rate with respect to the price of the flat rate. Previously in Chapter III the following was shown

$$\frac{\partial P_{i1}}{\partial X_1} = \beta P_{i1}(1-P_{i1}) .$$

if the above expression is evaluated with $P = .85$ to reflect the probability of selecting the flat rate from the entire sample, $\frac{\partial P_{1j}}{\partial X_1} = -0.002$. This result indicates that, at least for some range around the current flat rate price, changes in the flat rate have a negligible effect on the number of subscribers.

Further evidence of this lack of sensitivity of the "take rate" to price of flat service is found in Figure 3. This graph illustrates bill-minimizing behavior in terms of number of calls where each call is of length three minutes. Survey results obtained by Peter Merrill Associates, Inc. indicate that the average number of monthly calls by households subscribing to the flat rate is in the vicinity of 175 calls per month. As Figure 3 illustrates, at this number of calls the flat rate would have to increase nearly 100% to make its price comparable to the bill under either of the measured options. Thus, it seems clear that increases in the flat rate would have to be very large to affect behavior at the typical 175 call level. Of course it is also possible that customers might elect to switch to measured service and "repress" or cut down their usage in order to avoid large bills under the flat rate pricing scheme. As Figure 3 suggests, the current flat rate expenditure on either measured option would only purchase about 75 calls each month, less than half the number of calls usually made

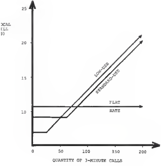

Figure 3. Bill as a Function of the Number of 3-Minute Calls.

by flat rate subscribers. This represents a great compromise in the number of local calls made each month. The truth may lie somewhere between these scenarios. The empirical results suggest that the flat "take rate" will not be influenced by price increases of a moderate type. Increases of 50% in flat rate price, normally a large increase, probably will not affect the "take rate." The empirical results and the analysis of the bill-minimizing customer behavior both suggest that this insensitivity is the case.

Selected Elasticity Estimates

Table 5 gives some selected elasticities calculated at the means of the variables. These elasticities reflect the impact a 1% change in each variable would have on the proportion of customers subscribing to the flat rate option. The table is based primarily on variables that were of special importance or highly significant. These results suggest that the number of telephones in the household greatly increases the flat rate subscription. It is also apparent that the length of time one spends in a neighborhood increases the probability of choosing flat rate. Thus, one might expect flat rate subscription to be high in older neighborhoods. Another obvious result is the striking similarity between the elasticities estimated by NMNL and the 2-choice logit method. This is consistent with the presumption that the measured options are similar, and could

be pooled into a single measured category with little loss of information.

Uncontrolled Influences

There are some factors which influence the class of service choice that could not be accounted for in this analysis due to data deficiencies. It is useful, however, to discuss these influences and speculate as to how they effect the choice of service class.

One factor that cannot be controlled is risk averse behavior on the part of customers. One trait of the bill under flat rate pricing is consistency. The bills do not change. Under measured service the bill certainly will vary from month to month. Some customers will be willing to pay a premium to avoid this uncertainty. For those risk averse individuals, increases in the flat rate will have to be even more substantial to cause a shift to a measured option.

Another factor that could not be controlled due to the lack of data is the customer's location within the calling area. Local calls in the Jupiter experiment were also differentiated by distance. There were two tiers around the Jupiter calling areas, and calls placed to the farther tier were more expensive. One might expect that most calls placed by a customer are to the surrounding neighborhood. If this is the case then those individuals living near the tier borders will have to make a large number of calls to other tiers, since their neighborhood encompasses the other

tiers. Thus, these border dwelling customers will find measured service more expensive since calling across the street could be calling another tier. Those individuals who are located centrally in the Jupiter exchange may not have this problem, and for this reason may be more disposed toward measured service. Data were not available to determine where in the Jupiter area each customer lived. Certainly, this issue is important for any pricing policy.

Another frequent criticism of class of service choice models is that calling patterns differ greatly from month to month, and the danger of observing these patterns for too short a time period may make the relation between calls and rate choice less precise. This problem may have been side-stepped in this study. The actual calling patterns of the customers were not used, and the choice was modeled in terms of the perceived calling patterns. If the perceived calling patterns are independent of the rate choice, and it seems they should be, this problem has been avoided.

One final difficulty occurs with the fact that measured service is now optional. Since some customers will have measured service, while others will not, it will be in the interest of the measured customers to always be called by their friends who subscribe to the flat rate. One can envision signalling procedures among these local callers not unlike those procedures currently used by college students for toll calls. Households on measured service could signal their friends who subscribe to flat service by ringing their

telephones a specified number of times, after which the flat rate subscriber would place the call. The extent to which this could occur in the local market is difficult to ascertain, but it will somewhat lessen calling revenues since some measured calls will now be priced under a flat rate scheme at a marginal price of zero.

These represent some of the data deficiencies of this study. The effects of these variables on balance seems to be to reinforce the previous findings that the flat rate would have to be increased substantially if its "take rate" were to be expected to fall.

Note

[1]The correction of the covariances in the second stage is given by Amemiya (1978). If Σ_2 denotes the estimated variance-covariance matrix in the second stage, Σ_1 denotes the variance-covariance matrix in stage one, and Σ_{21} denotes the covariance matrix between the first and second stage estimates, the adjusted variance-covariance matrix of stage two or Σ_2^* is thus,

$$\Sigma_2^* = \Sigma_2 + \Sigma_2 \Sigma_{21} \Sigma_1 \Sigma_{12} \Sigma_2 .$$

CHAPTER V

CONCLUSIONS

The Attractiveness of LMS

The implementation of measured service at some time in the near future is certain. There are several reasons why measured service looks like the trend of the future in the pricing of local telephone calls.

There have been regulatory changes occurring in the telecommunications industry. Competition has been allowed in the toll market, reducing revenues from which local service had previously been subsidized. The loss or reduction of market power in the toll and terminal equipment markets will lessen subsidies available for local service. Local service could be salvaged by simply increasing the flat rate, but this would price some customers out of the market for a telephone. Since universal service at reasonable prices is one of the goals of the telephone industry, this solution is not satisfactory.

LMS could be used, in the absence of subsidies from the toll and terminal equipment markets, to provide low cost local telephone service. By offering low access charges, LMS still provides service at a low connection fee, thereby still permitting the attainment of a universal service goal.

By charging separately for usage, LMS will bring customers' bills more in line with their calling costs. Customers who make excessive numbers of local calls would, under LMS, have large bills. Infrequent callers would have low monthly bills. This would eliminate the subsidy from low callers to high callers which occurs under a flat-rate pricing scheme. LMS could solve the revenue problem caused by the subsidy loss without making telephone service too expensive for some to afford.

Another problem connected to the above occurs because the telephone industry is subject to rate of return regulation. It has been shown by Averch and Johnson (1962) that this constraint leads to overcapitalization. This capital has accumulated due to the subsidies available for local service. There are also peaks in telephone usage over time. LMS will permit revenues to be generated for capital if it is necessary. Those customers requiring additional capital will be paying for it.

Rising energy prices have made the telephone more prominent in household search activities. This has led to increased telephone traffic, but under flat rate pricing no additional revenues are generated. LMS would cause additional traffic to generate additional revenues.

Increased urbanization has also increased the demand for local calls, with no increase in revenues under a flat rate pricing scheme. LMS provides a solution.

LMS has now become practical because the costs of monitoring a line have dropped to only $5 per line per year. Increased technology has made LMS a possibility that can be explored.

Murphy (1977) gives a different view of the implementation of LMS options. He argues that the provision of LMS options is actually a form of price discrimination. It is well known that a monopolist could perfectly price discriminate if enough information on individual demands was available and arbitrage was expensive. In the case of local telephone service, arbitrage would be relatively expensive, and the collection of information on individual demands would be very costly. The provision of LMS options then provides an explicit metering system for local calls. The consumers essentially identify themselves. This metering system also provides a hedge against shift in the demand for local calls in the future. Proper selection of these LMS options would permit a discriminating monopolist to increase profits without gathering data on individual demands. Thus, LMS options may well enhance the profitability of the telephone company.

Major Findings

LMS will soon become a reality, but there has been no previous empirical research on the implementation of LMS options. The following section provides a summary of the findings of this dissertation.

This research provided some insight into what customer groups preferred measured service. One of the strongest empirical results was that LMS appealed to well-educated low callers. Due to the pricing schedules presented in the measured options, low callers nearly always chose LMS because they could reduce their bills. The well-educated group is composed of individuals who are able to understand the more complex LMS price schemes. Because of the pricing options offered, only low callers switched to LMS in order to reduce their bills.

Another finding of this study is the perceived similarity between the low-use measured option, and the standard use measured option. The approximate correlation coefficient between the two was .43. In light of the pricing schedules offered, this is really no surprise. Based on the number and duration of calls customers believed they made each month, the average bills for the Jupiter sample were as follows: low-use, $20.73; standard-use, $20.29; and flat rate, $10.65. The difference between the low-use and standard use bills was only 44 cents. In addition to not differing monetarily, the measured options were both new, and presented very similar pricing schemes. The similarity of the measured options was certainly enhanced by the low charge under the flat rate. If the flat rate were substantially increased, possibly 50%, customers would carefully examine LMS options in order to avoid large bills. This careful examination would lead to increased

discrimination between the two measured options. Thus, the high similarity is probably only a manifestation of the experimental design.

A tendency was also found for customers who have telephones available at their worksites to select measured service, and shift some calls to the worksite, thereby reducing their bills. This tendency is reflected in the estimated coefficients of some of the occupational category dummy variables. It is not possible to assess the amount of traffic that might be switched to businesses based on the results of this dissertation. The matter should be explored further. Mitchell and Park (1981) also note that substitution of local calls to businesses represents another possibility caused by offering optional measured service.

Comments on the Experimental Design

Finally, the experiment itself must be discussed. The experiment was poorly designed from the standpoint of gathering information about customers' responses to various price schedules. First of all, participation in the experiment was voluntary. Those individuals who did not care to find out about measured service simply did not participate. Secondly, there were only three pricing options offered, and one of those was the same flat rate to which all participants in the experiment had previously subscribed. The limited number of options offered did not allow the participants to react to a variety of different

options. Elasticities could not be calculated. The pricing options were composed of three parts: The access charge, the call allowance, and the usage charge. These price parameters were not varied so customer responses to changes in them could not be determined. The flat rate was not increased in the experiment, so most customers had no incentive to thoroughly explore the LMS options. As noted in Chapter IV, if most customers maintained the calling habits under the flat rate, and then switched to LMS, their bills would more than double. Thus, only the low callers had an incentive to switch to LMS and participate in the experiment. Any attempt to increase the flat rate would simply be met by a large portion of the sample quitting the experiment. The voluntary participation makes it impossible to obtain any information by increasing the flat rate.

There are a few suggestions for further empirical research on optional classes of measured service which are implied by the previous comments. The experiment would yield useful results if the pricing parameters involved, that is the access charge, the call allowance, and the usage charge all were varied. Participation in the experiment should be mandatory, but some incentive system, such as compensation could be paid to each participant based on their previous calling history. The pricing option then would consist of an access charge, a call allowance, a usage charge, and some monetary compensation. These compensations would differ from participant to participant, and the impact

of the compensation could be netted out of the statistical analysis to yield customer responses to the three pricing parameters mentioned above. These results would indicate how various customer groups react to different combinations of access charge, call allowance, and usage charge, which is exactly the information desired.

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BIOGRAPHICAL SKETCH

Steven Brant Caudill was born October 4, 1954, in Portsmouth, Ohio, the first child of Donal Caudill and Nona Justine Stumbo. He graduated from Marion-Franklin High School in Columbus, Ohio, in June, 1972. He then attended Ohio Wesleyan University in Delaware, Ohio, and received a Bachelor of Arts degree in mathematics in June, 1976. He received a Master of Arts degree in economics from the University of Florida in June, 1978. A doctoral degree is expected from the University of Florida in August, 1982.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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